Climate Change Impacts on Food Security and Nutritional Outcomes in Nigeria: Challenges and Policy Options

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ABSTRACT

The alarming rate of incidences of floods, drought, ocean heat, changes in snow and rainfall patterns, heavy rainstorms, increased frequency of heavy precipitation, depleting soil nutrients, and dwindling environmental quality indicates that climate change can cause severe risks to food security and nutritional outcomes in Nigeria. With all the pieces of evidence of climate change, only one percent of total arable land is equipped for irrigation in Nigeria. This study examines the impact of climate change on food security and nutritional outcomes in Nigeria. The study showed the country's readiness to tackle climate change and its vulnerability to climate change. The devastating impact of climate change on agricultural productivity, food insecurity, the number of people undernourished, and the average protein and dietary energy supply were revealed. The extent of climate change impact was reported alongside relevant policy directions to tackle climate change and reduce the prevalence of food insecurity in Nigeria.

INTRODUCTION

Food security is vital for the attainment of the United Nations Sustainable Development Goals (SDGs). This is because, healthy and well-nourished people are the primary focus of sustainable development. Food security is achieved when all people at all time have economic, social, and physical access to nutritious, safe, and sufficient food that satisfies their food preferences and dietary needs for an active and healthy life.

The dimensions of food security include:

- Adequate food utilization.
- Physical and economic access to food.
- The physical availability of food.

However, adequate food utilization depends on the ability of one's body to process and use nutritious materials.[1] Being an important global concern, food security is closely related with nutrition, human health, the climate, and other internal and external factors. These 'other' factors include corruption, poor policy implementation, gender inequality, and insufficient food production.[2]

Climate change is real, with visible catastrophic evidence across countries of the world. Climate manifest through various avenues like rising global temperature, retreating glaciers, sea level rising, drought, famine, decreasing snow cover, ocean acidification, ocean heat, changes in snow and rainfall pattern, heavy rainstorm, increased frequency of heavy precipitation, depleting soil nutrient, and stress to ecosystem.[3]

All the manifestations of climate change are a major risk to sustainable development and development outcomes. Nigeria is presently dealing with different environmental challenges, some of which are aggravated by climate change, and adversely impact every sector, particularly infrastructure, water resources, and agriculture.[4] Other challenges facing Nigeria are de-vegetation and deforestation, causing the dwindling of biocapacity and land degradation; desertification, drought, erosion, floods which are degrading the environment. As a result, most Nigerians still have limited access to safe water and poor sanitation.

[1] FAO, and ECA (2018). Regional Overview of Food Security and Nutrition. Addressing the threat from climate variability and extremes for food security and nutrition. Accra: Food and Agriculture Organization of the United Nations.
[2] Sohail, M. T., Mustafa, S., Ali, M. M., & Riaz, S. (2023). Agricultural communities' risk assessment and the effects of climate change: A pathway toward green productivity and sustainable development. Front. Eco-innovation and green productivity for sustainable production and consumption, 16648714, 123.
[3] Kumar, P., Sahu, N. C., Ansari, M. A., & Kumar, S. (2023). Climate change and rice production in India: role of ecological and carbon footprint. Journal of Agribusiness in Developing and Emerging Economies, 13(2), 260-278.
[4] World Bank Data Bank (2023). World Development Indicators, Nigeria. URL: https://databank.worldbank.org/source/world. Accessed: 25/4/2023.

Table 1 below shows the population (total, rural, and urban) using safely managed drinking water services and the population using safely managed sanitation services.

Climate change refers to a degree of change in the mean variable properties of the climate over a long period, usually one or two decades or longer. On the flip side, the climatic condition refers to the long-term summation of atmospheric elements like precipitation, relative humidity, temperature, and solar radiation and their variations over a long period. A continuous variation from the mean or/and variability properties is what is termed climate change. The main driver of climate change is the human proliferation of the greenhouse effect.[5]

Human-induced factors, such as household energy consumption, urbanization, deforestation, and burning fossil fuels for transportation, agriculture, and industries, amplify the atmospheric concentration of greenhouse gases (GHGs), thereby increasing global temperature and global warming that follows it.[6,7]

Global warming, which is a clear manifestation of climate change, is triggered by the trapping of heat radiated from earth towards space by GHGs like chlorofluorocarbons (CFCs), methane (CH4), carbon dioxide (CO2), and nitrous oxide (N2O).

These GHGs, in their natural occurrence, serve as a support system to the earth by keeping the atmosphere warm enough to support the existence of organisms, including animals and plants. However, anthropogenic activities such as human agricultural and industrial activities have accelerated the emissions of noxious gases into the atmosphere resulting in the expansion of GHGs, which promotes global warming. Also, the changes in the natural level of GHGs, especially in its expansion, make the earth warmer.[8] The warmer condition of the earth's atmosphere gives rise to increased precipitation and evaporation across different regions of the world. The greenhouse effect also triggers the warming of oceans, leading to the melting of ice sheets and glaciers and rising sea levels.

[5] IPCC (2014), "Global climate change impacts in the United States", Fifth assessment report of the United States Global Change Research programme, Cambridge University Press.
[6] Nathaniel, S. P., Solomon, C. J., Ajide, K. B., Ahmed, Z., & Fakher, H. A. (2023). Striving towards carbon neutrality in emerging markets: the combined influence of international tourism and eco-friendly technology. International Journal of Sustainable Development & World Ecology, 1-16.
[7] Bedeke, S. B. (2023). Climate change vulnerability and adaptation of crop producers in sub-Saharan Africa: A review on concepts, approaches and methods. Environment, Development and Sustainability, 25(2), 1017-1051.
[8] Haj-Amor, Z., Araya, T., Kim, D. G., Bouri, S., Lee, J., Ghiloufi, W., ... & Lal, R. (2022). Soil salinity and its associated effects on soil microorganisms, greenhouse gas emissions, crop yield, biodiversity and desertification: A review. Science of the Total Environment, 843, 156946.

The warmer condition of the earth's atmosphere gives rise to increased precipitation and evaporation across different regions of the world. The greenhouse effect also triggers the warming of oceans, leading to the melting of ice sheets and glaciers and rising sea levels. Evidence from empirical findings shows that the concentration of these noxious gases in the atmosphere can negatively affect crop yield.[9,10]

Furthermore, the evidence from the extant literature suggests that some categories of crops are adversely affected, whereas other crops do well under extreme weather conditions. Climate change has led to losses in agricultural produce, soil infertility, and droughts and has threatened the livelihood of farmers and food security in the past and in recent times. The threat posed by climate change on environmental health, nutrition outcomes, and food security has generated global concern leading to different conferences, initiatives and measures to curb the menace.

Some of these conferences and initiatives include the First Earth Summit held in Stockholm, Sweden, in 1972, where principles for the enhancement and preservation of the human environment were highlighted. Another is The Paris Agreement, adopted by 196 countries at the UN Climate Change Conference (COP21) in Paris, France, in 2015. COP21 came into force in November 2016. The most recent, tagged COP27, was held in Sharm El Sheikh, Egypt, between November 6 and November 20, 2022.

According to FAO, IFAD, UNICEF, WFP, and WHO (2017,2018,2019),[11,12,13] the three factors responsible for food crisis include crisis (internal or external), national economy, and climate. In Nigeria, these three factors have a significant influence in the country's food security system.

[**9**] Shakoor, A., Shahbaz, M., Farooq, T. H., Sahar, N. E., Shahzad, S. M., Altaf, M. M., & Ashraf, M. (2021). A global meta-analysis of greenhouse gases emission and crop yield under no-tillage as compared to conventional tillage. Science of the Total Environment, 750, 142299.

[10] Guo, C., Liu, X., & He, X. (2022). A global meta-analysis of crop yield and agricultural greenhouse gas emissions under nitrogen fertilizer application. Science of The Total Environment, 831, 154982.

[**11**] FAO, IFAD, UNICEF, WFP and WHO (2017), "The state of food security and nutrition in the world 2017", Building Resilience for Peace and Food Security, FAO, Rome.

[12] FAO, IFAD, UNICEF, WFP and WHO (2018), "The state of food security and nutrition in the world 2018", Building Climate Resilience for Food Security and Nutrition, FAO, Rome.

[13] FAO, IFAD, UNICEF, WFP and WHO (2019), "The state of food security and nutrition in the world 2019", Safeguarding against Economic Slowdowns and Downturns, FAO, Rome.

STYLIZED FACTS

TABLE 1: ACCESS TO SAFE DRINKING WATER AND PROPER SANITATION (% OF THE POPULATION)

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
People using safely managed drinking water services, rural (% of rural population)	13.67	14.08	14.48	14.88	15.28	15.68	16.07	16.47	16.86	17.25	17.65
People using safely managed drinking water services (% of population)	17.93	18.32	18.72	19.10	19.48	19.86	20.23	20.60	20.96	21.3`	21.66
People using safely managed drinking water services, urban (% of urban population)	23.46	23.65	23.84	24.03	24.23	24.42	24.61	24.80	25.00	25.19	25.38
People using safely managed sanitation services (% of population)	25.07	25.55	26.05	26.56	27.08	27.62	28.17	28.73	29.31	29.90	30.50

Source: World Bank Data Bank (2023)

Nigeria is not immune to the negative effects of climate change. The adverse effects of climate change are visible across the vegetative regions of the country, particularly in the northern and southern regions. Climate change poses a threat to agricultural productivity in Nigeria.[14,15] Some agricultural lands are now flooded with increased acidity and aridity of the Sudan and Sahel savanna belt. Some of the effects of climate change on agriculture productivity leading to food insecurity in Nigeria include alteration in relative humidity, rising temperature, heavy rainfall or cessation of rainfall, and heavy precipitation.[16]

All these have contributed to low productivity, poverty, crop damage, hunger, armed conflict, securitization, herdsmen attack, international displacement, disruption in the food supply, rising food prices, hoarding of agricultural products, scarcity of food, and death. Food scarcity has led to malnutrition and incessant health challenges, especially for children.[17]

[14] Akano, O., Modirwa, S., Oluwasemire, K., & Oladele, O. (2023). Awareness and perception of climate change by smallholder farmers in two agroecological zones of Oyo state Southwest Nigeria. GeoJournal, 88(1), 39-68.
[15] Pickson, R. B., Gui, P., Chen, A., & Boateng, E. (2023). Examining the impacts of climate change and political instability on rice production: empirical evidence from Nigeria. Environmental Science and Pollution Research, 1-20.
[16] Anyaegbu, C. N., Okpara, K. E., Taweepreda, W., Akeju, D., Techato, K., Onyeneke, R. U., ... & Pongpiachan, S. (2022). Impact of Climate Change on Cassava Yield in Nigeria: An Autoregressive Distributed Lag Bound Approach. Agriculture, 13(1), 80.
[17] Omodara, O. D., Ige, O. A., Oluwasola, O., Oyebanji, A. T., & Afape, O. O. (2023). Factors influencing cassava farmers' choice of climate change adaption practices and its effect on cassava productivity in Nigeria. Heliyon, 9(3).

The ND-GAIN Index[18] ranks countries of the world using score to calculate the countries vulnerability to climate change and other global environmental challenges and their readiness to improve resilience. Regarding the combinations of social, geographical, and political factors, Nigeria was considered a country vulnerable to climate change impacts and ranked 160 out of the results reported for 181 countries. In the ND-GAIN Index,[19] the more vulnerable a country is the lower their score. Conversely, the more ready a country is to improve its resilience, the higher it will be. From Table 1, the number of people using safely managed drinking water services, rural (% of rural population) increased from 13.67 percent in 2010 to 15.68 percent in 2015.

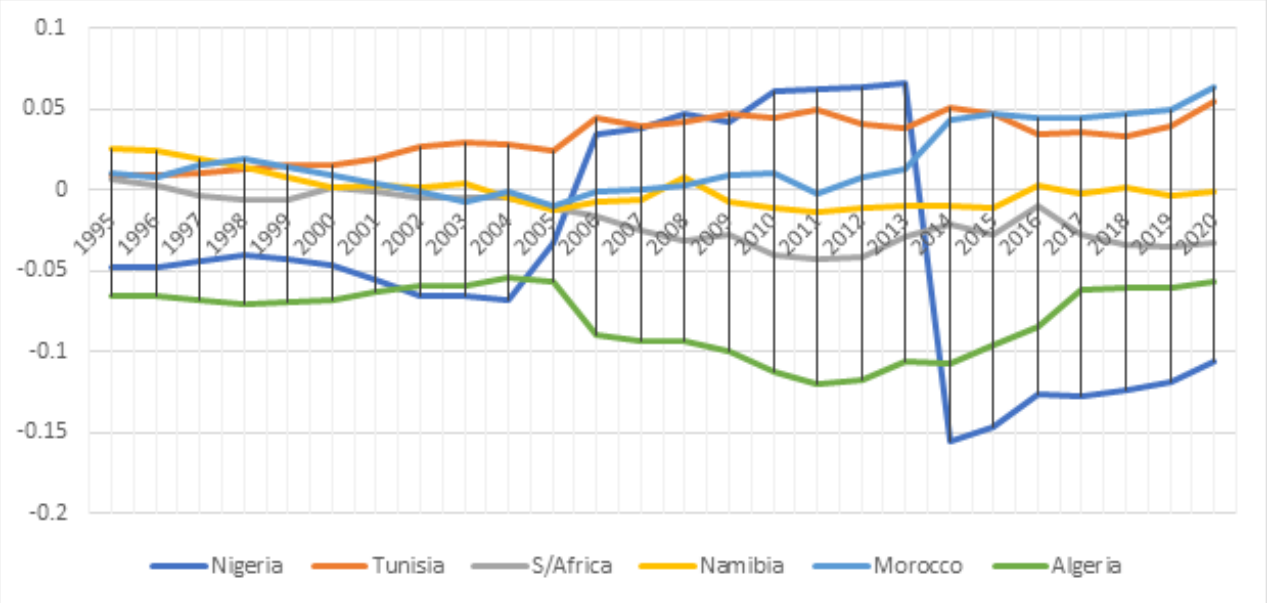
The number increased minimally from 15.68 percent in 2015 to 17.65 percent in 2020. The number of People using safely managed drinking water services (% of population) did not witness any significant improvement between 2010 and 2020. It increased from 17.93 percent in 2010 to 21.66 percent in 2020, representing a marginal 3.73 percent increase. This outcome suggests that the number of people using safely managed drinking water services in rural areas (% of rural population) has only increased by 3.98 percent.

This is far lower than what is obtainable in other lower-middle-income countries like Ecuador, Egypt, Cambodia, Indonesia, Iran, Morocco, and India. The number of people using safely managed sanitation services (% of population) has only minimally increased by 5.43 percent in the decade between 2010 and 2020.

Worst still, the number of people using safely managed drinking water services, urban (% of urban population) only managed to increase by 1.92 percent between 2010 and 2020. Figure 1 shows the degree of readiness to improve resilience among selected African countries. The evidence from the chart showed that the readiness to improve resilience has reduced drastically in 2013. The readiness to improve resilience is still very low in Nigeria compared to what is obtainable in other African countries.

[18] University of Notre Dame (2023). Notre Dame Global Adaptation Initiative. URL: https://gain.nd.edu/our-work/country-index/
[19] IBID

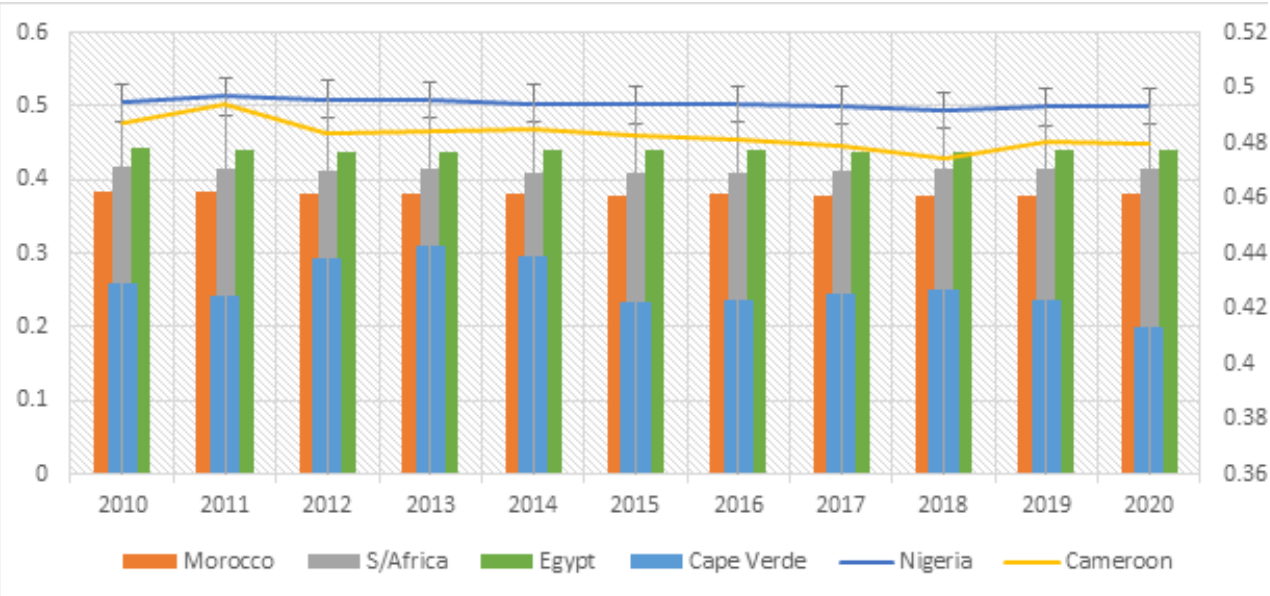
FIGURE 1: READINESS TO IMPROVE RESILIENCE



Source: Notre Dame Global Adaptation Initiative (2023).[5]

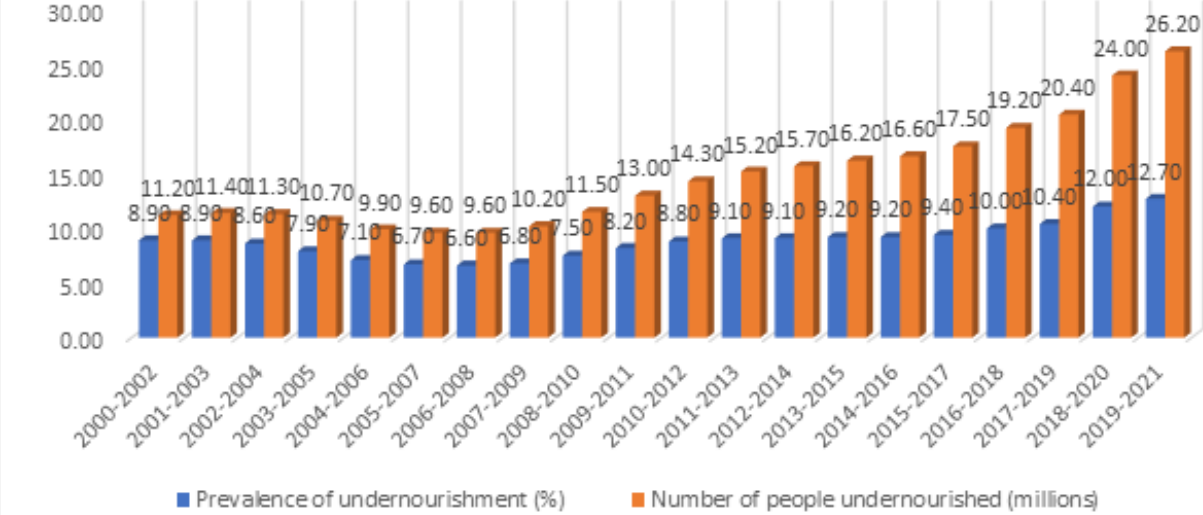
Figure 2 reveals that Nigeria is among the countries highly vulnerable to climate change compared to countries like Cape Verde, Cameroon, South Africa, Morocco, and Egypt. This is expected because Nigeria is characterized by three district climate zone, a Sahelian hot and semi-arid climate in the northern part of the country, a tropical savannah climate in most of the central regions, and a tropical wet climate in the south.

FIGURE 2: DEGREE OF VULNERABILITY TO CLIMATE CHANGE



Source: Notre Dame Global Adaptation Initiative (2023).[5]

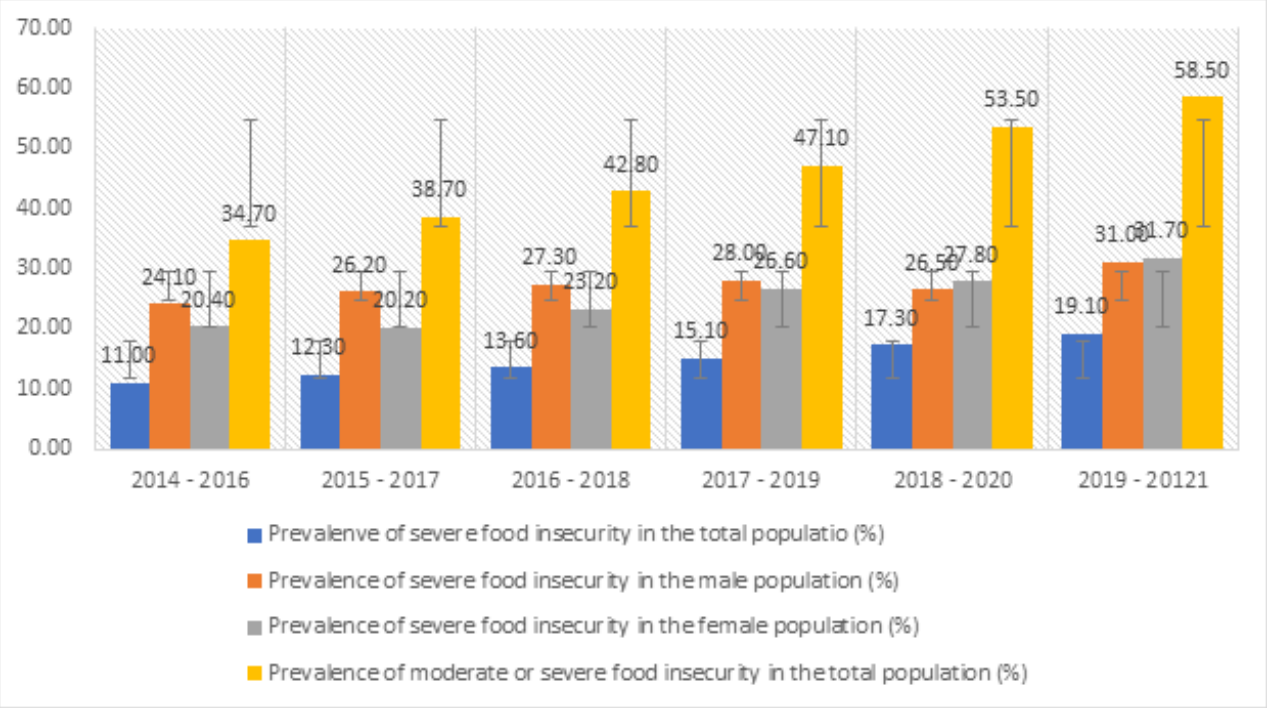
FIGURE 3: PREVALENCE OF UNDERNOURISHMENT VERSUS NUMBER OF PEOPLE UNDERNOURISHED



Sources: FAO (2023)[19]

Figure 3 shows the prevalence of undernourishment (in percentage) in Nigeria versus number of people undernourished (millions). Between 2000 and 2002, the prevalence of undernourishment (in percentage) was 8.90 percent in Nigeria. There was a minimal decrease between 2002 -2004 and 2010 – 2012. However, after 2010 – 2012, the number increased from 9.10 percent in 2011 – 2013 to 12.70 in 2019 – 2021. From 2012 till date, the prevalence of undernourishment has witnessed a steady increase in Nigeria. Also, the number of people undernourished (millions) exceeded 26 million in 2021.

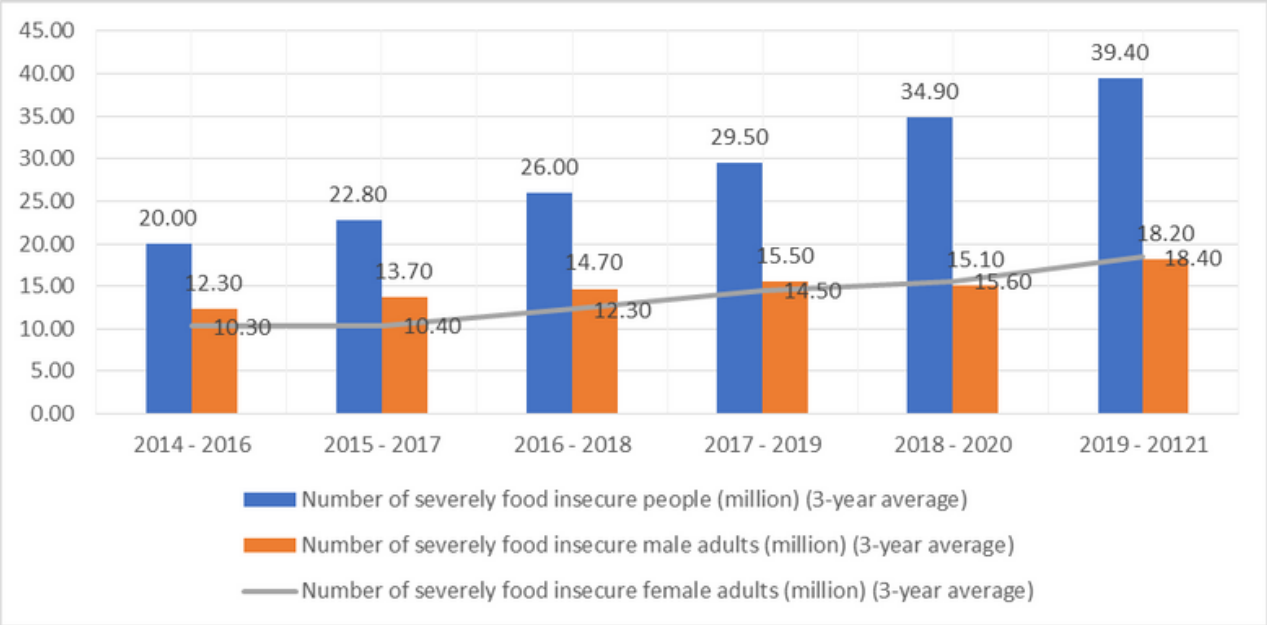
FIGURE 4: SELECTED INDICATORS OF THE PREVALENCE OF SEVERE FOOD INSECURITY



Sources: FAO (2023)[19]

Figure 4 reveals the figures for the selected indicators for the prevalence of severe food insecurity in Nigeria. The prevalence of severe food insecurity in the total population (in percentage) increased steadily between 2014 and 2021. However, the prevalence of severe food insecurity in the male population (in percentage) increased from 24.10 percent between 2014 – 2016 to 28.00 percent between 2017 – 2019 and 31.03 percent between 2019 – 2021. On the other hand, the prevalence of severe food shortage in the female population (in percentage) reduced to 20.20 percent between 2015 and 2017, to 23.20 percent between 2016 and 2018, and 31.70 percent between 2019 and 2020. Also, the prevalence of moderate or severe food insecurity in the population increased from 34.70 percent between 2014 – 2016 to 58.50 percent between 2019 – 2021.

FIGURE 5: INDICATORS OF SEVERE FOOD INSECURE PEOPLE



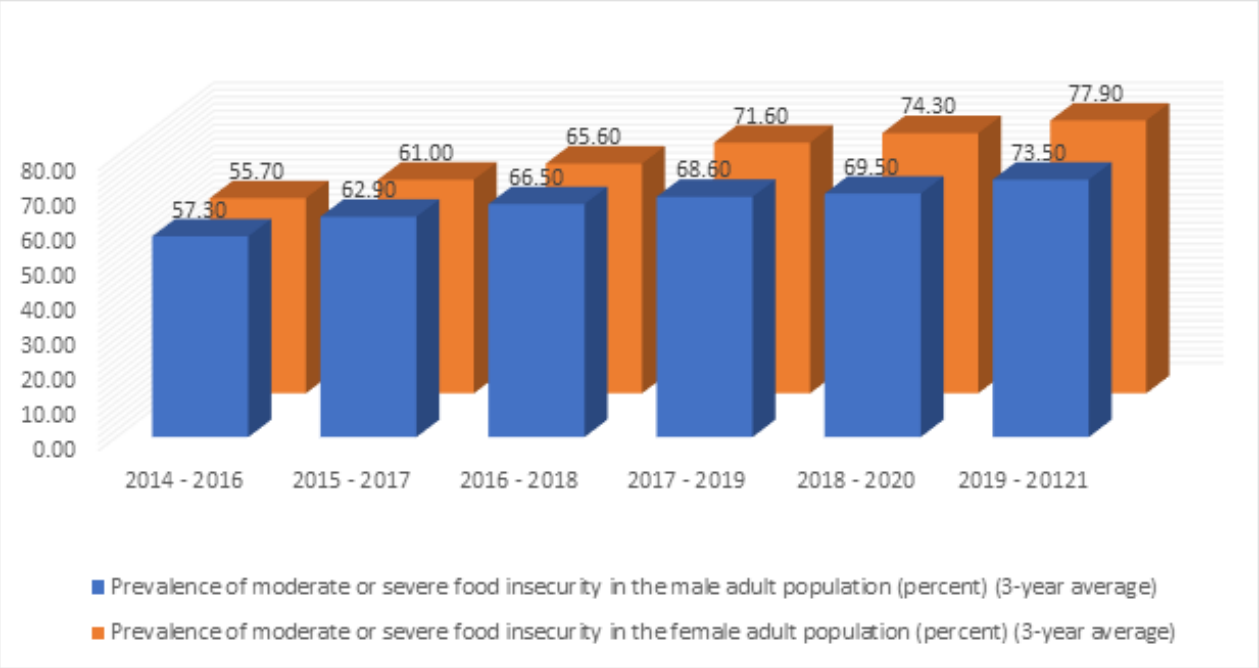
Sources: FAO (2023)[19]

Figure 5 shows the number of severely food-insecure people (millions) has continued to increase over the years. The number almost doubled between 2014 – 2016 and 2019 – 2021. This could have resulted from the adverse effects of climate change on agricultural produce in Nigeria[20]. The number of severely food-insecure male adults (millions) was higher than that of food-insecure female adults (millions) between 2014 – 2016 and 2017 – 2019. However, the number of food-insecure female adults (millions) exceeded the number of food-insecure male adults (millions) between 2018 -2020 and 2019 – 2021.This outcome suggests that from 2018, female adults suffer more from severe food insecurity than their male counterparts in Nigeria.

Figure 6 shows the figures for the prevalence of moderate or severe food insecurity in the male adult population (in percentage) and the prevalence of moderate or severe food insecurity in the female adult population (in percentage). The evidence from the figure (Figure 6) shows that the male adult population suffer more from moderate or severe food insecurity between 2014 – 2016 and 2016 – 2018. However, between 2017 – 2019 and 2019 – 2021, the female adult population suffered more from moderate or severe food insecurity in Nigeria. Food insecurity remains a serious problem that requires prompt actions from policymakers in Nigeria.

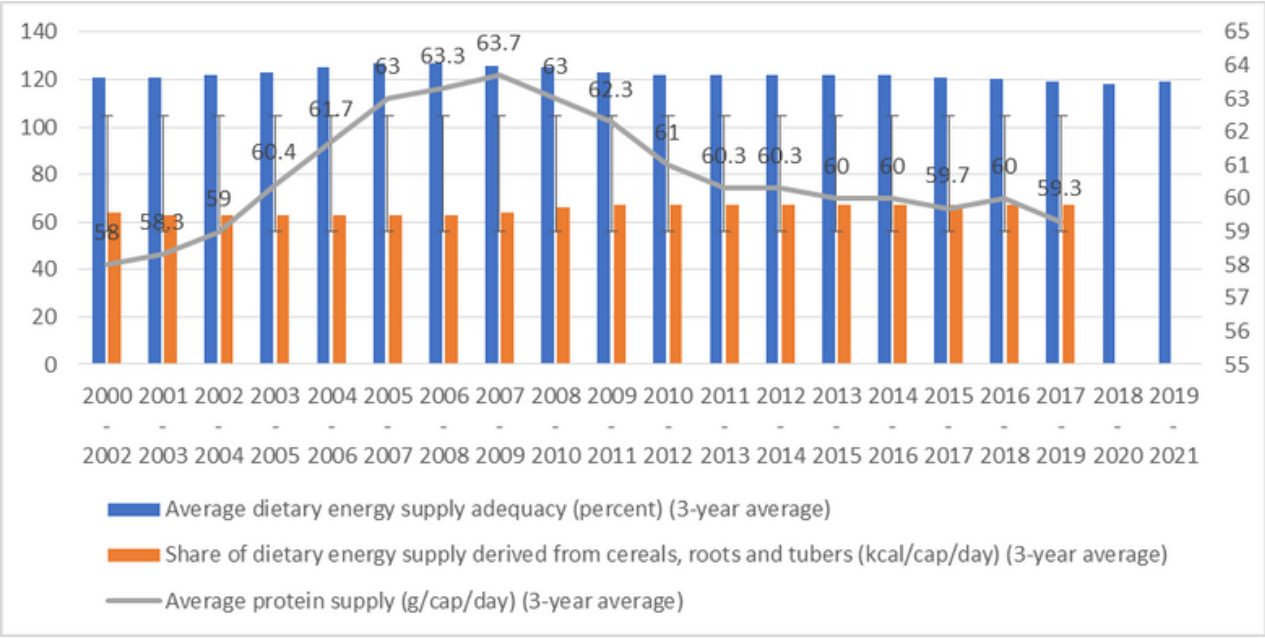
[20] IPCC (2014), "Global climate change impacts in the United States", Fifth assessment report of the United States Global Change Research programme, Cambridge University Press.

FIGURE 6: MODERATE AND SEVERE FOOD INSECURITY IN MALES AND FEMALES IN NIGERIA



Sources: FAO (2023)[19]

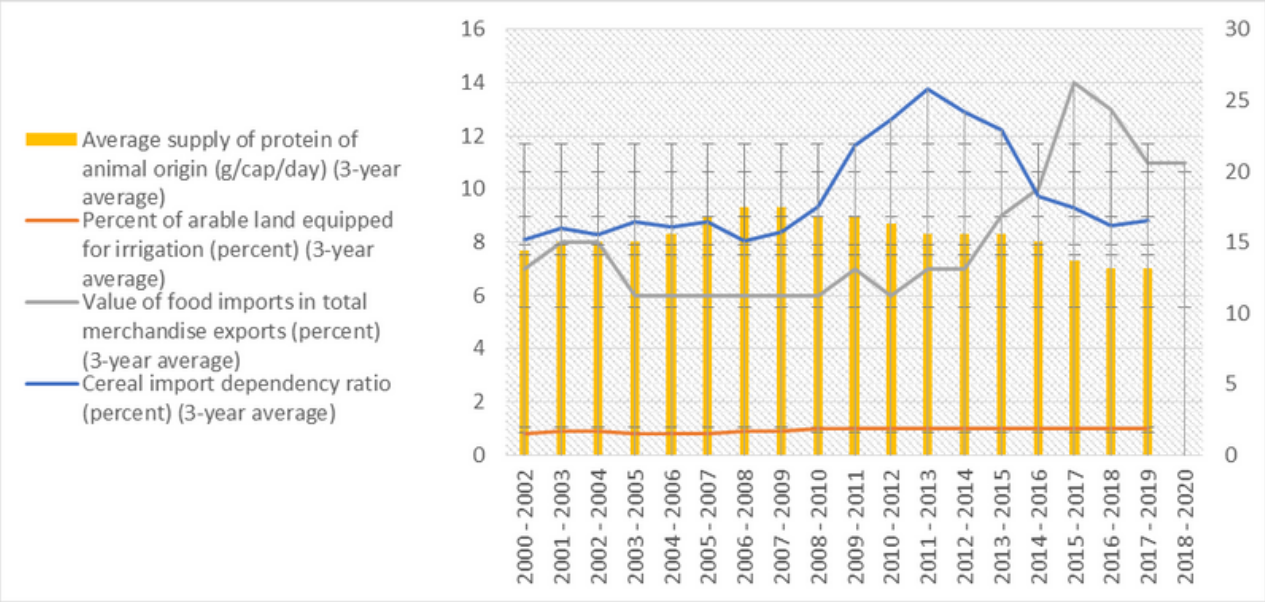
FIGURE 7: DIETARY ENERGY AND PROTEIN SUPPLY



Sources: FAO (2023)[19]

From Figure 7, the average protein supply has dwindled since 2007. The average dietary energy supply has not improved since 2010. However, the share of dietary supply derived from cereals, roots, and tubers has only increased slightly from 64 kcal between 2007 – 2009 to 67 kcal between 2017 – 2019.

FIGURE 8: ARABLE LAND FOR IRRIGATION, CEREAL IMPORT, FOOD IMPORT, AND SUPPLY OF PROTEIN



Sources: FAO (2023)[19]

Figure 8 reveals that the average supply of protein of animal origin has continued to decline after it peaked between 2007 – 2009. The percentage of arable land equipped for irrigation has been less than 1 percent. However, it remained at 1 percent between 2008 – 2010 and 2017 – 2019. This shows the limited attention accorded to climate change and food security issues in Nigeria. On the other hand, the value of food imports in total merchandise exports witnessed a steady rise between 2012 – 2014 and 2015 – 2017. However, the cereal import dependency ratio (%) started declining after it peaked in 2011.

IDENTIFIED CHALLENGES

Many studies have affirmed that the climatic vagaries associated with climate change have created environmental challenges, affecting agricultural activities, leading to lower productive outputs and food insecurity.[21]
Climate change has contributed to low food quality and nutritional composition of food crops in Nigeria. This exposes people to consuming harmful products that might hurt their health or leave them with permanent health challenges.

The component of the energy source (non-renewable energies) consumed in Nigeria triggers carbon emissions concentration in the atmosphere and exposes crops to noxious gases. The exposition of food crops to high carbon emissions concentration reduces produce quality and hurts human health.[22,23]
In all, some of the identified challenges posed by climate change on food security in Nigeria include:

- **The Alteration of Planting and Harvesting Seasons**: Climate change gives rise to whether variations in Nigeria. It has intermittently altered the rainfall onset and sunshine pattern in different parts of the country, especially in the northern region where agriculture is the mainstay of their economy.

These climatic vagaries have impacted the planting and harvesting seasons of some food crops, subsequently leading to the scarcity or unavailability of some crops, even in periods where there should be a glut of produce on the market. Foodstuff scarcity triggers a rise in food prices and increases the prevalence of severe food insecurity.

- **Decrease in Crop Yield:** One of the reasons for decreased crop yield is due to the amount of carbon emissions concentration in the atmosphere. This could have either positive or adverse effects on crop yield because not all crops do well under such conditions. Again, changes to environmental conditions like increased flood and soil acidity, drought, rising temperature, increased precipitation, heavy rain, frequent and severe heat wave, and melting ice caps triggered by climate change lead to decreased crop quality and yield.

- **Increased Pest:** Changes in temperature and humidity and the variations in rainfall onset have increased the breeding of various pests that attack animals and food crops in Nigeria.

[21] Oyinloye, J. A., Oyekunle, J. A. O., Ogunfowokan, A. O., Msagati, T., Adekunle, A. S., & Nety, S. S. (2021). Human health risk assessments of organochlorine pesticides in some food crops from Esa-Oke farm settlement, Osun State, Nigeria. Heliyon, 7(7), e07470.
[22] IBID
[23] Berhanu, M., & Wolde, A. O. (2019). Review on climate change impacts and its adaptation strategies on food security in sub-Saharan Africa. Agricultural Socio-Economics Journal, 19(3), 145-154.

Different species of pests have evolved with damming impacts on food crops and agricultural productivity, thereby increasing the prevalence of undernourishment and food insecurity in Nigeria.

- **Influence on Livestock:** Climate change does not only threaten livestock; the persistent heat wave emanating from climate change has also led to the loss of animals. High temperature, a manifestation of carbon emissions concentration in the atmosphere, has enhanced the vulnerability of livestock to different diseases, reducing their fertility. Drought exacerbates food insecurity because livestock that depends on foliage may need to endure longer periods of undernutrition and food shortage.

- **Flooding of Farmlands:** Rising sea levels and incessant rainfall result in flooding in most states. Flooding of farmlands is not alien to Nigeria, especially for the inhabitants of the South-South and South-East region of the country. Besides, flooding leads to the loss of species, uncultivatable farmlands, disruption of agricultural activities, and, subsequently, agricultural produce.

- **High demands for Irrigation:** Climate change can influence the frequency and intensity of precipitation. A warmer ocean increases the amount of water that evaporates into the air. When more moisture-laden air converges into a storm system, it results in more intense precipitation, e.g., snow rain and heavy rain. However, this does not refute the fact that climate change can also lower the level of rainfall. There is low rainfall in the Sudan and Sahel savanna belts of the country, which has encouraged using irrigation facilities as an alternative for producing water. The use of irrigation will increase the cost of farming, which will increase food prices. Besides, farmers that cannot afford irrigation may be forced to go out of business which can cause food shortages.

POLICY OPTIONS

Having seen the effects of climate change on food security and nutritional outcomes in Nigeria, a comprehensive strategy is suggested to proffering solutions to the root causes of the problems. The following policies are recommended to enhance food security and improve nutritional outcomes in Nigeria.

- First, adequate legislative policies promoting environmental-friendly practices should be encouraged. The government must intensify efforts to promote environmental awareness among the populace to encourage pro-environmental behaviour in waste management, efficient energy consumption, and support for environmental policies. Anthropogenetic activities like deforestation, gas flaring, illegal waterway construction, and over-exploration of natural resources should be prohibited. Effective climate legislation would uphold conservative practices, including recycling, and minimize human-induced factors that drive climate change.
- More research in natural and climatological sciences should be embarked on to promote more beneficial and robust alternatives to natural agriculture production patterns to guarantee food security and sustainable nutritional outcomes. Research should be tailored towards developing animal and crop varieties with short maturity periods that can be minimally affected by reduced rainfall and extreme temperature.
- Agricultural methods or smart food systems less vulnerable and resistant to climate change should be adopted to promote food security and sustainable nutritional outcomes.
- Alternative practices like recharging shrinking water bodies and using irrigation in the Sahel and Sudan savannah region should be facilitated by the government and other stakeholders to ensure that farmers that could not afford irrigation facilities are streamed back into farming activities. If this is done, it will not only increase agricultural productivity but also reduce the prices of food.

POLICY OPTIONS

- The propagation of drought-resistant grasses is required in areas affected by drought. This will go a long way to decline the tide of pastoral north-south migration patterns witnessed over the years in Nigeria. Moreover, it will also reduce the farmers-herdsmen threaten the peace and security of farmers in the middle-belt and other regions of the country.

REFERENCES

FAO, and ECA (2018). Regional Overview of Food Security and Nutrition. Addressing the threat from climate variability and extremes for food security and nutrition. Accra: Food and Agriculture Organization of the United Nations.

Sohail, M. T., Mustafa, S., Ali, M. M., & Riaz, S. (2023). Agricultural communities' risk assessment and the effects of climate change: A pathway toward green productivity and sustainable development. Front. Eco-innovation and green productivity for sustainable production and consumption, 16648714, 123.

Kumar, P., Sahu, N. C., Ansari, M. A., & Kumar, S. (2023). Climate change and rice production in India: role of ecological and carbon footprint. Journal of Agribusiness in Developing and Emerging Economies, 13(2), 260-278.

Akano, O., Modirwa, S., Oluwasemire, K., & Oladele, O. (2023). Awareness and perception of climate change by smallholder farmers in two agroecological zones of Oyo state Southwest Nigeria. GeoJournal, 88(1), 39-68.

World Bank Data Bank (2023). World Development Indicators, Nigeria. URL: https://databank.worldbank.org/source/world.

University of Notre Dame (2023). Notre Dame Global Adaptation Initiative. URL: https://gain.nd.edu/our-work/country-index/

IPCC (2014), "Global climate change impacts in the United States", Fifth assessment report of the United States Global Change Research programme, Cambridge University Press.

Nathaniel, S. P., Solomon, C. J., Ajide, K. B., Ahmed, Z., & Fakher, H. A. (2023). Striving towards carbon neutrality in emerging markets: the combined influence of international tourism and eco-friendly technology. *International Journal of Sustainable Development & World Ecology*, 1-16.

Bedeke, S. B. (2023). Climate change vulnerability and adaptation of crop producers in sub-Saharan Africa: A review on concepts, approaches and methods. Environment, Development and Sustainability, 25(2), 1017-1051.

Haj-Amor, Z., Araya, T., Kim, D. G., Bouri, S., Lee, J., Ghiloufi, W., ... & Lal, R. (2022). Soil salinity and its associated effects on soil microorganisms, greenhouse gas emissions, crop yield, biodiversity and desertification: A review. Science of the Total Environment, 843, 156946.

Shakoor, A., Shahbaz, M., Farooq, T. H., Sahar, N. E., Shahzad, S. M., Altaf, M. M., & Ashraf, M. (2021). A global meta-analysis of greenhouse gases emission and crop yield under no-tillage as compared to conventional tillage. Science of the Total Environment, 750, 142299.

Guo, C., Liu, X., & He, X. (2022). A global meta-analysis of crop yield and agricultural greenhouse gas emissions under nitrogen fertilizer application. *Science of The Total Environment*, *831*, 154982.

FAO, IFAD, UNICEF, WFP and WHO (2017), "The state of food security and nutrition in the world 2017", Building Resilience for Peace and Food Security, FAO, Rome.

FAO, IFAD, UNICEF, WFP and WHO (2018), "The state of food security and nutrition in the world 2018", Building Climate Resilience for Food Security and Nutrition, FAO, Rome.

FAO, IFAD, UNICEF, WFP and WHO (2019), "The state of food security and nutrition in the world 2019", Safeguarding against Economic Slowdowns and Downturns, FAO, Rome.

Akano, O., Modirwa, S., Oluwasemire, K., & Oladele, O. (2023). Awareness and perception of climate change by smallholder farmers in two agroecological zones of Oyo state Southwest Nigeria. GeoJournal, 88(1), 39-68.

Pickson, R. B., Gui, P., Chen, A., & Boateng, E. (2023). Examining the impacts of climate change and political instability on rice production: empirical evidence from Nigeria. *Environmental Science and Pollution Research*, 1-20.

Anyaegbu, C. N., Okpara, K. E., Taweepreda, W., Akeju, D., Techato, K., Onyeneke, R. U., ... & Pongpiachan, S. (2022). Impact of Climate Change on Cassava Yield in Nigeria: An Autoregressive Distributed Lag Bound Approach. Agriculture, 13(1), 80.

Omodara, O. D., Ige, O. A., Oluwasola, O., Oyebanji, A. T., & Afape, O. O. (2023). Factors influencing cassava farmers' choice of climate change adaption practices and its effect on cassava productivity in Nigeria. Heliyon, 9(3).

Food and Agricultural Organization (FAO) (2023). Sustainable Development Goals. https://www.fao.org/sustainable-development-goals/indicators/211/en/

Oyinloye, J. A., Oyekunle, J. A. O., Ogunfowokan, A. O., Msagati, T., Adekunle, A. S., & Nety, S. S. (2021). Human health risk assessments of organochlorine pesticides in some food crops from Esa-Oke farm settlement, Osun State, Nigeria. *Heliyon*, *7*(7), e07470.

Ani, K. J., Anyika, V. O., & Mutambara, E. (2022). The impact of climate change on food and human security in Nigeria. *International Journal of Climate Change Strategies and Management*, *14*(2), 148-167.

Berhanu, M., & Wolde, A. O. (2019). Review on climate change impacts and its adaptation strategies on food security in sub-Saharan Africa. *Agricultural Socio-Economics Journal*, *19*(3), 145-154.

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